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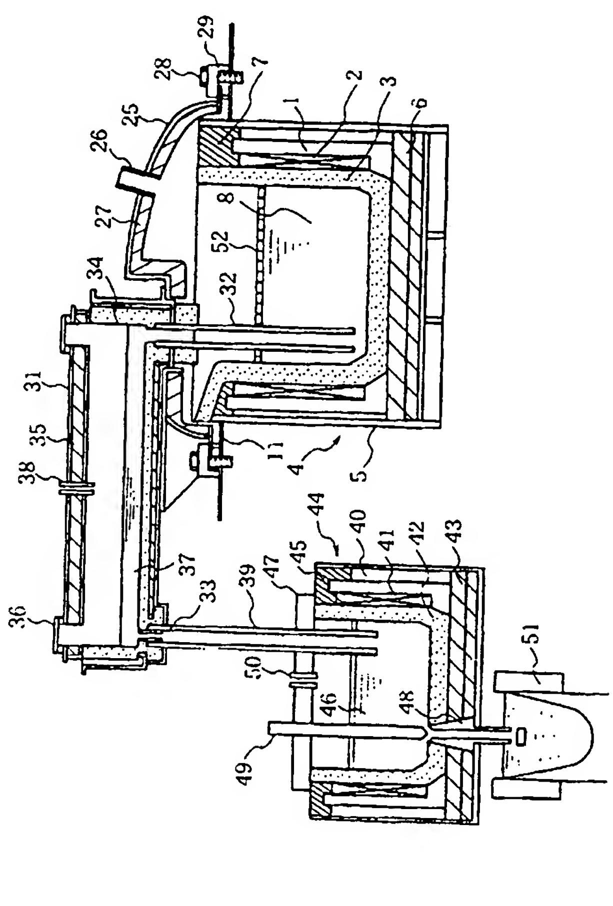
(54) Method of manufacturing copper alloy containing active metal

(57) When a copper alloy containing a metal more reactive with oxygen than copper is melted and cast, a feedstock is vacuum melted with an induction melting furnace (4) within an airtight container (5) which has been vacuum evacuated, and thereafter positive pressure is applied (via pipe 26) to the airtight container (5), and the molten metal is discharged from the furnace through a pouring siphon (32) for continuously casting in a mold (51). Said positive pressure is exerted using an inert gas.

FIG.2



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Description

The present invention relates to a method of manufacturing a copper alloy ingot containing an active metal.

In melting a copper alloy containing a metal which has a greater chemical affinity for oxygen than copper (hereinafter called "active metal"), for example, iron, titanium, chromium, zirconium, etc., it is indispensable to prevent oxidation of the active metal within the copper alloy for enhancing the yield of the active metal and ingot quality. Therefore, the so-called vacuum melting method which has been used heretofore to melt the copper alloy in an induction melting furnace placed within an airtight container which has been vacuum evacuated (hereinafter called "melting furnace"), is an effective means for preventing oxidation of the copper alloy.

On the other hand, a vacuum casting method which makes a casting into a mold housed within the airtight container of the melting furnace is effective as a means to cast molten metal under such a state as to preserve the cleanliness of the molten metal which has been vacuum melted. However, a casting within the airtight container having a limited space will be limited to the so-called ingot making process in which such fabrication of the thus obtained ingot as forgoing and scalping, etc. will be needed before a hot rolling.

No effective means has been provided for removing the slag generated during the vacuum melting in the above mentioned prior art as the melting fumace is housed within an airtight container, and thus it has been necessary to limit the feedstock to be molten. Therefore, it has usually been necessary to avoid the use of scrap and to melt only a so-called virgin feedstock for reducing the amount of the slag generated to the minimum level possible. However, when the molten metal is cast into a mold, the melting furnace is tilted to pour the molten metal, and thus it will be unavoidable that the slag which has been generated will flow into a pouring spout along with the tilting of the melting furnace and will contaminate the mold.

On the other hand, when a large size ingot is needed the entire airtight container housing the melting furnace and molds must be made larger in the vacuum melting-vacuum casting method, and in addition, an increase of a vacuum evacuation capacity will be needed.

Also, a casting with a continuous casting process is desirable for producing a large size ingot which can be directly hot rolled from the standpoint of cost competitiveness. However, it takes a huge amount of investment for housing the entire continuous casting equipment within the airtight container. It might be a realistic approach to avoid such an increase in equipment cost to pour the molten metal which has been vacuum melted into a transfer path to a continuous casting equipment such as a runner under the atmosphere or under a protective ambient atmosphere. However, slag flowing in along with the tilting of the melting furnace as well as the oxidation of the active metal at the pouring spout and in the transfer path will be unavoidable, which could severely impair the quality of the ingot.

The present invention is made in view of what has been described above, and has the object of providing a method of manufacturing a copper alloy containing an active metal, which can restrain the generation of slag even if scrap is molten as feedstock in melting and casting of the copper alloy containing the active metal, and which can pour the molten metal to the outside of the furnace without including the slag, and at the same time can manufacture a large size ingot with satisfactory cleanliness by continous casting.

The present invention relates to a method of manufacturing a copper alloy containing an active metal for achieving the above mentioned object, and comprises a method of manufacturing a copper alloy containing an active metal wherein when the copper alloy containing the active metal is melted and cast, a feedstock is vacuum melted by an induction melting furnace within an airtight container which has been vacuum evacuated, and then pressure is applied to the airtight container, whereby the molten metal is cast into a continuous casting mold through a pouring siphon.

Further, the present invention may comprise the following features (the subject of the appended subclaims):

(1) A method in which the airtight container, which is tightly closed with a vacuum melting furnace cover and can be vacuum evacuated, is vacuum evacuated by a vacuum evacuating pipe, then the furnace cover is replaced with a pressure pouring furnace cover having a pouring siphon penetrated therethrough, then the airtight container is tightly closed and pressure is applied from a pressure pipe to the inside of the airtight container;

(2) A method in which an intermediate portion of said pouring siphon is formed as a pouring chamber in which a liquid surface of the molten metal is protected by an inert gas atmosphere, and an inlet side of said siphon is formed as an inflow part with its lower end opened to a bottom part of said induction melting furnace, and then an outlet part thereof is formed as a mold pouring part having a pouring nozzle, whereby the molten metal flowing in the pouring siphon is virtually prevented from oxidation;

(3) A method in which the molten metal poured from the pouring nozzle is accumulated in a molten metal receptacle and then the molten metal poured from a casting nozzle provided at a bottom of the receptacle is continuously cast;

(4) A method in which a scrap is used at least as a portion of the feedstock to be molten;

(5) A method in which pressure is applied an inert gas to the inside of the airtight container tightly closed with the pressure pouring furnace cover; and

(6) A method in which a liquid surface of the molten metal within the molten metal receptacle is protected by an

inert gas.

A method to apply pressure from the pressure pipe and pour the molten metal, which has been vacuum melted, continuously from the pouring nozzle by utilizing the pouring siphon and further to continuously cast the molten metal poured from the pouring nozzle can be employed.

When the melting and casting process is composed as provided in the present invention, of slag generated during the vacuum induction melting can be restrained even if the feedstock is scrap, and when the pouring is made under pressure by utilizing the pouring siphon after the melting, the casting can be made while avoiding oxidation of the metal and the inclusion of the slag at a time when the melting furnace is tilted, and a scalping, etc. can be eliminated in an after treatment for the continuously cast ingot.

The function of the present invention will be described in a more detailed manner, by way of non-limitative explanation.

First, a metal of a copper alloy containing an active metal or a scrap is fed into a melting furnace, then a vacuum melting furnace cover is assembled to an upper end of an airtight container housing the melting furnace, and the container is tightly closed, thus forming the so-called vacuum melting furnace. Also, the inside of the airtight container is evacuated through a vacuum evacuation pipe to a desired pressure level by a vacuum evacuation device. Then, the feedstock or scrap in the melting furnace is melted by an induction heating.

As the feedstock in the furnace is vacuum melted by the induction heating, the oxidation of the copper alloy can be prevented. Also, when scrap is used as the feedstock, the generation of slag at the time of melting cannot be prevented but, since the melting is done under vacuum, the generation of the slag can be largely restrained as compared to melting under the atmosphere. Further, when electric power of a level at which the temperature of the molten metal under vacuum will not fall is maintained after completion of the melting of the charged feedstock, the molten metal is allowed to settle when the slag generated during the melting floats to the surface of the molten metal because of its different specific gravity compared with the molten metal.

Next, the furnace cover is replaced from the vacuum melting furnace cover by the pressure pouring furnace cover and the latter furnace cover is fixed in place, and thus the airtight container is tightly closed again. While the molten metal within the furnace is briefly exposed to the atmosphere when the replacement is made to the pressure pouring furnace cover, the layer of the slag which floats up to the surface of the molten metal constitutes a covering film, and thus the oxidation of the molten metal within the furnace is restrained, minimised or largely prevented.

When pressure, which is controlled by a pouring pressure control device, is applied to the inside of the airtight container through the pressure pipe in the pressure pouring furnace cover to push down the surface of the molten metal in the melting furnace, the molten metal within the furnace ascends the pouring siphon, which extends to the bottom part of the melting furnace and constitutes the only outlet to the outside from the furnace, is raised to a pouring chamber, and then is poured from a pouring nozzle provided at the other end of the pouring chamber to a continous casting machine. The molten metal, which has been raised by pressure from the pouring siphon to the pouring chamber, thus pours from the pouring nozzle to the continuous casting machine. The slag which has floated to the top of the melt remains floating at the surface of molten metal in the furnace until a prescribed amount of molten metal has been expelled, and is not included in the molten metal poured into the continuous casting machine.

Also, if the molten metal poured from the pouring nozzle is received by a molten metal receptacle such as a tundish, etc., the molten metal is stored within the molten metal receptacle, oxides which has been unavoidably included float up and separate again, and the molten metal poured to the continuous casting machine from a casting nozzle provided at a bottom of the molten metal receptacle, molten metal having a further high level of cleanliness can be cast.

Further, if the application of the pressure to the inside of the airtight container which is tightly closed with the pressure pouring furnace cover, is made with an inert gas and the inside of the molten metal receptacle such as a molten metal receiving chamber, a tundish, etc. is provided with an inert atmosphere, oxidation of the molten metal in a molten metal transfer path from the melting furnace to the continuous casting machine can be prevented.

The invention will now be described in more detail by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a partially cross sectional schematic view illustrating the case when a vacuum melting furnace cover is mounted; and

Fig. 2 is a cross sectional schematic view illustrating the case when a pressure pouring furnace cover is mounted.

A method of manufacturing copper alloys containing active metal according to the present invention will be explained taking the case of Cu - 1% Fe alloy as an example. % figures quoted herein are in accordance with normal metallurgical practice, unless indicated to the contrary.

White the active metal contained in the copper alloy in this example is iron and the amount contained is 1 weight %, this constitutes merely one embodiment of the present invention and the iron content is not to limit the scope of the

present invention. Also, while iron is taken in this example as the active metal contained in the copper alloy and explanations are made therefor, this also is not to limit the scope of the present invention. The active metal in the present invention indicates every metal element having greater chemical affinity for oxygen than copper. Therefore, aluminum, etc. is also included therein in addition to the kinds of metal listed previously. Also, the copper alloy may include one, two or more kinds of different active metal and other metal than the active metal.

The composition of copper bullion, electrolytic iron, and alloy scrap was so determined that the ratio of scrap in the feedstock to be melted was adjusted to be 30%.

Fig. 1 is a partially cross sectional view of an airtight container 5 housing an induction melting furnace 4 of a coreless crucible type, and a vacuum melting furnace cover 9 is mounted on an upper end of the container 5.

In this drawing, 1 is a yoke, 2 represents heating coils, 3 is a crucible, 6 shows heat insulating bricks, 7 is a castable refractory, all of which are known in relation to an induction furnace. What is shown as 11 is packing. In use of the equipment shown in Fig. 1, the inside of the airtight container 5 is evacuated by a vacuum pump (not shown in the drawing) through a vacuum evacuation pipe 12, and the feedstock which had been charged beforehand into the melting furnace 4 is vacuum melted. The remainder of the feedstock, during the melting operation, is additionally charged to the inside of the melting furnace 4 is several divided portions of charges by lowering, using an elevating device 19, a feedstock charging bucket 18 in a feedstock charging device 13, provided above the vacuum melting furnace cover 9 which is lined with heat insulating material 10. At this time, a gate valve 14 is opened by an air cylinder 15, and after charging with feedstock the gate valve 14 is closed again and the inside of the melting furnace is evacuated. What is shown as 17 is a feedstock charging chamber door for releasing the feedstock charging device 13 when the feedstock charging bucket 18 is replaced. Here, the inside of the feedstock charging device 13 can also be evacuated by a vacuum pump (not shown in the drawing) through a vacuum evacuation pipe 16, so that the additional charging of feedstock may be done also under vacuum.

When melting of all the feedstock is completed reaching a state of burn through, a thermocouple 20 provided in a temperature sensing chamber 21 of a molten metal temperature sensing equipment 23 was pushed into the molten metal 8 for measuring the temperature thereof. After placing the molten metal in a holding state by adjusting the electric power to the induction heating coils, the vacuum melting furnace cover 9 and a pressure pouring furnace cover 25 (refer to Fig. 2) were replaced or interchanged by a shifting device not shown in the drawings.

Fig. 2 is a cross sectional view of the same airtight container 5 housing the induction heating furnace 4 of a coreless crucible type. Now shown is a pressure pouring furnace cover 25 which is assembled to an upperend of the container 5 with bolts 28 and a retaining metal fitting 29. When inert gas pressure, controlled by a pouring pressure control device (not shown in the drawing) is applied to the inside of the airtight container 5 through a pressure pipe 26 provided in the pressure pouring furnace cover 25, the surface of the molten metal 8, which is covered with a layer of slag, in the melting furnace 4 is pushed down, causing the molten metal to ascend a pouring siphon 32 which has been inserted so as to reach a bottom part of the melting furnace and is raised or pumped up to a pouring gutter 34 in a pouring chamber 31.

The upper part of the pouring chamber 31 is tightly closed with a pouring chamber closing cover 35, which can be opened and closed, and an inert gas is sealed in from a gas pipe 38 for preventing the oxidation of the molten metal 37 during pouring. Also, an electric heater (not shown in the drawing) is provided at a side wall of the pouring chamber 31 and the pouring gutter 34 within the pouring chamber 31 is heated by the electric heater to a temperature higher than the melting point of the copper alloy, whereby the molten metal within the pouring chamber 31 can be maintained at a constant temperature.

The molten metal 37 raised into the pouring chamber 31 through the pouring siphon 32 by pressuizing, is poured into a tundish 44 through a lance pipe 39 from a pouring nozzle 33 with which the pouring chamber 31 is provided, the rate or amount of pouring being controlled by control of the pressure applied to the inside of the airtight container 5 using a pressure control device (not shown in the drawing) so that a constant amount of the molten metal is continuously poured. At this time also, the level of the liquid surface of the molten metal 37 as well as the inflow behavior of the molten metal to the pouring nozzle 33 are observed through a peephole 36. Since the pouring siphon 32 reaches close to the bottom part of the furnace, the molten metal at the bottom of the furnace ascends in the pouring siphon 32 with the slag 30 kept afloat and separated. And thus floating slag 30 is kept atop the surface of the molten metal in the furnace until a prescribed amount of the molten metal has been discharged, so the slag will not contaminate the molten metal being poured to the tundish 44.

A casting nozzle 48 is provided at a bottom of the tundish 44. After closing the casting nozzle 48 e.g. with a stopper 49 and sufficient preheating is done by a gas burner (not shown in the drawing), the molten metal is received through the lance pipe 39 under pressurized pouring. When a prescribed amount of the molten metal 46 has been accumulated in the tundish 44, the stopper 49 is lifted by a control device (not shown in the drawing) to open the casting nozzle 48. Molten metal 46 is then supplied to the inside of a water cooled copper mold 51 in a semi-continuous casting equipment from the bottom of the tundish 44 through the casting nozzle 48, and is cooled and solidified. The thus-solidified ingot is continuously drawn vertically downwards with a constant speed by a hydraulic cylinder, not shown in the drawing.

At this time, a predetermined amount of the molten metal is stored in the tundish 44. Oxides of iron which have been unavoidably mixed into the molten metal 46 float to its surface and separate again. Thus only molten metal with a high level of cleanliness at the bottom part of the tundish flows into the casting nozzle 48 and is supplied to the continuous casting machine.

As the lance pipe 39 is connected beneath the pouring nozzle 33 and its forward end is inserted into the tundish 44, the molten metal descending from the pouring nozzle 33 enters the inside of the tundish 44 without being exposed to the atmosphere. Also, an upper part of the tundish 44 is tightly closed with a tight closing cover 47 which can be opened and closed, and inert gas supplied from a gas pipe 50 is sealed therein, thus preventing oxidation of the molten metal received in the tundish.

Moreover, the molten metal 46 stored in the tundish 44 is induction heated by a heating coil 41 provided in the tundish 44, so the molten metal can always be kept at a constant temperature.

As a comparative example, feedstock prepared totally from alloy bullion was, after vacuum melting, continuously cast by an atmospheric pouring, i.e. unprotected from the air, by tilting the furnace.

An ingot thus melted and cast was cut in half and after polishing a cross section the distribution of oxides of iron was observed by microscopic observation, and the results thereof are shown in Table 1.

Table 1 shows the number of oxides of iron per 1 cm^2 when an observation was made for an observation area in the cross section of 20 cm^2, as well as the maximum length of the oxide inclusions.

As apparent from Table 1, the number of oxides or iron contained in Cu -1% Fe ingot manufactured by the method of the present invention was largely reduced as compared to that in the prior art, and the maximum length of the oxide inclusions was shortened by about 1/8, so the size of oxide particles was very significantly reduced.

TABLE 1

	Ratio of Scrap in Feedstock	Melting Method	Pouring Method	No. of Inclusions No./Cm^2	Maximum Length of Inclusions μm
Present Invention	30%	Vacuum	Pressure Pouring	0.1	95
Comparative Case	0%	Vacuum	Tilting of Furnace Atmospheric Tapping	35.6	830

According to the method of manufacturing a copper alloy containing an active metal of the present invention, a continuous casting can be made without including the slag which has inevitably been generated. Therefore even when scrap, which cannot be used in a conventional vacuum melting, is melted as a feedstock, a pour can be made without including the generated slag. Moreover, molten metal free of large size oxides, which were contained in the molten metal but have been flated free and separated, can be continuously cast, thus realizing an effect that melting and casting of the copper alloy containing an active metal can be produced at low cost and an ingot of a high qaulity with little contamination can be obtained.

Claims

1. A method of manufacturing a copper alloy containing an active metal wherein when the copper alloy containing the active metal is melted and cast, after a feedstock is vacuum melted with an induction melting furnace (4) placed in an airtight container (5) which has been vacuum evacuated, pressure is applied to said airtight container (5) and molten metal is cast via a pouring siphon (32) into a continuous casting mold (51).

2. A method of manufacturing a copper alloy containing an active metal according to claim 1, wherein the airtight container (5), which is tightly closed with a vacuum melting furnace cover (9) and can be vacuum evacuated, is vacuum evacuated by a vacuum evacuating pipe (12), then the furnace cover is replaced with a pressure pouring furnace cover (25) having a pouring siphon (32), and when said airtight container is tightly closed pressure is applied from a pressure pipe (26) to the inside of the airtight container (5).

3. A method of manufacturing a copper alloy containing an active metal according to claim 2, wherein an intermediate portion of said pouring siphon (32) is formed as a pouring chamber (31) in which a liquid surface of the molten metal is protected by an inert gas atmosphere, and an inlet side of said siphon (32) is formed as an inflow part

with its lower end opening to a bottom part of said induction melting furnace (4), and an outlet part thereof is formed as a pouring part (33) having a pouring nozzle (39), whereby molten metal flowing in the pouring siphon (32) is virtually prevented from contact with air and oxidation.

4. A method of manufacturing a copper alloy containing an active metal according to claim 3, wherein the molten metal poured from the pouring nozzle (39) is accumulated in a molten metal receptacle (44) and the molten metal is poured from a casting nozzle (48) provided at a bottom of said receptable and is continuously cast.

5. A method of manufacturing a copper alloy containing an active metal according to any one of claims 1 to 4, wherein a scrap is used at least as a part of the feedstock to be melted.

6. A method of manufacturing a copper alloy containing an active metal according to any one of claims 2 to 5, wherein pressure is applied with an inert gas to the inside of the airtight container (5) when tightly closed by the pressure pouring furnace cover (25).

7. A method of manufacturing a copper alloy containing an active metal according to any one of claims 4 to 6, wherein a liquid surface of the molten metal within said molten metal receptacle (44) is protected with an inert gas.

8. A copper alloy containing one or more alloying elements more reactive with oxygen than copper, having fewer and smaller oxide particles dispersed therein than the same alloy melted and cast in air, which is obtainable by the method according to any of the preceding claims.

FIG.1

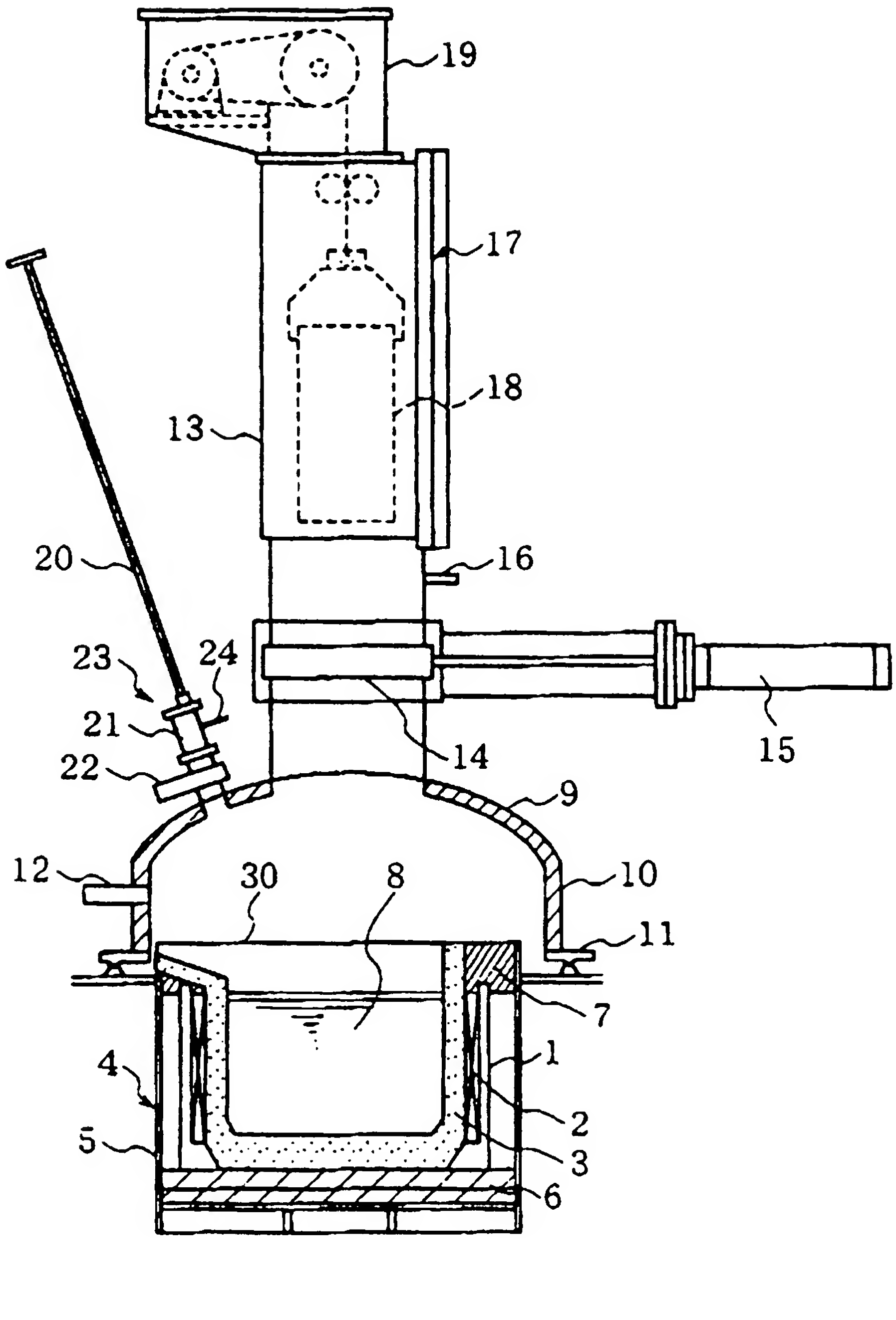
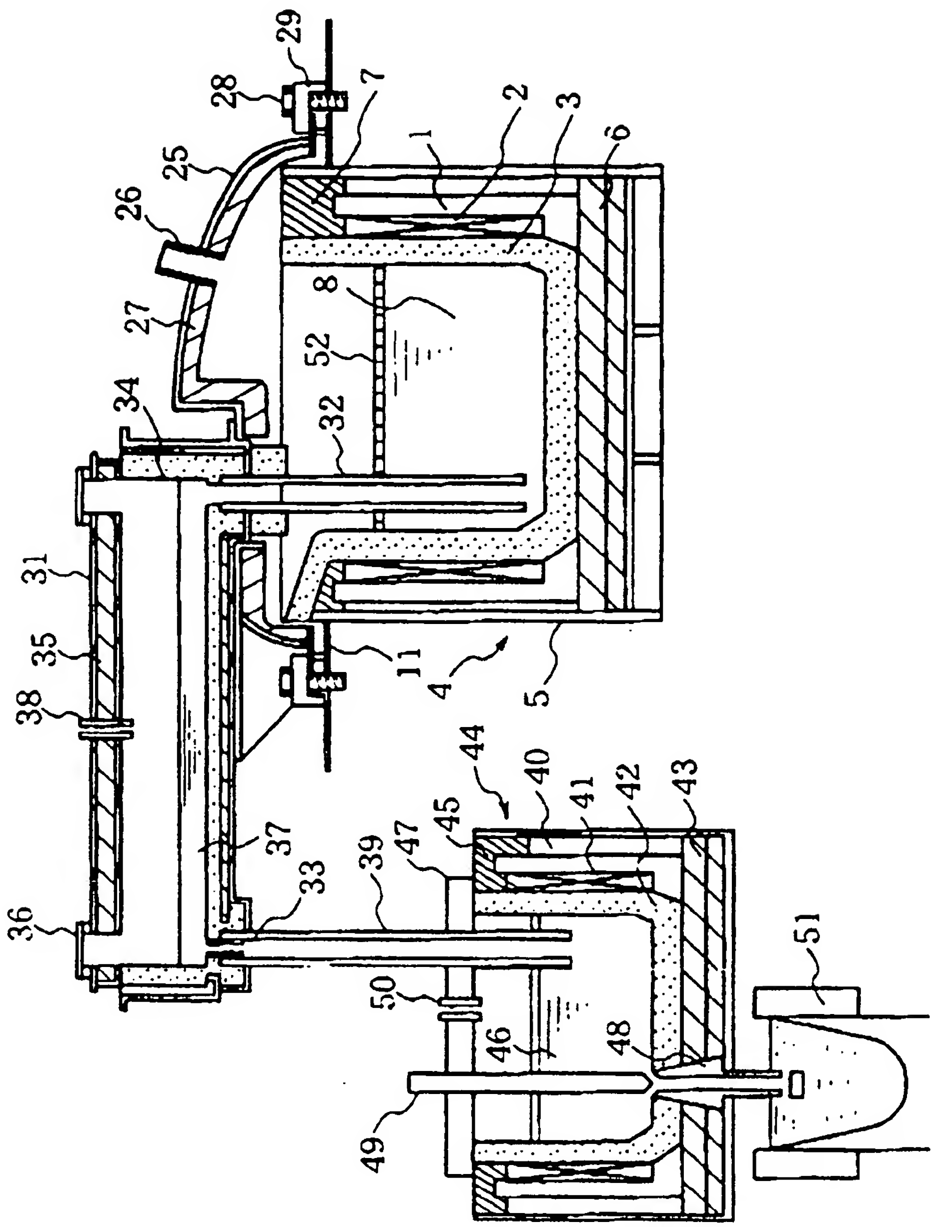


FIG.2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